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Sub-irrigation Methods for Growing Potatoes in Containers Under a Rainshelter

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Abstract

Potatoes were grown in a polyethylene-covered rainshelter at an 850 m elevation in Hawaii. Nutrient solution (1.5 mS) depths of 2.5 to 5 cm were maintained in growing tanks (3.7 m long x 0.6 m wide) by gravity flow to float valves. Two 'Catalina' potato tubers were planted in bottom-perforated polyethylene bags supported by the tank floor and 3 tubers were planted in nursery trays (17x17x5 cm) elevated 5 cm above the tank floor. The bags and trays contained 2 liters of growing medium per potato seed tuber and these containers were subsequently 'hilled' 3 times with dry grass. Total salable yields of potatoes growing in nursery trays and 11.4 and 18.9-liter bags were 5.4, 4.6 and 5.1 kg/m² (based upon tank area), respectively. In another experiment, no significant yield differences were observed from 'All Blue' and 'Catalina' potatoes which were grown similarly in 18.9-liter bags, in 10-cm slit-sided pots supported by a 2.5 cm-thick expanded polystyrene top-cover for the tank, and when potato seed tubers were wrapped in newspaper which rested on 5-cm-high nursery tray. All 3 treatments were hilled with dry grass. Bottom-perforated 8-liter pots containing upside-down 3-liter pots were filled with 5 liters of 3 growing media and these pots were sub-irrigated. Total salable yields of 'All Blue' potatoes in peat-perlite, silty clay loam soil or decayed wood chips were 4.9, 2.1 and 5.4 kg/m², respectively. There was no yield advantage from planting 6 'Catalina' seed potatoes per bag as compared to 2 potatoes/bag. However, salable potato yields from bags planted with 4, 20 and 52 g ($\pm 15\%$) seed tubers were 5.2, 6.5 and 7.5 kg/m², respectively.

INTRODUCTION

Hawaii grows less than 1 % of approximately 17 million kg of potatoes which are consumed in the State annually (Hudson, 2003). Soil-diseases, nematodes, high rainfall and the lack of soil in some locations make it very difficult for Hawaii growers to economically produce general commodity-type potatoes. However, there is a niche market for high value potatoes such as gourmet potatoes for restaurants and seed potatoes which could be produced in polyethylene-covered rainshelters by a soilless growing method. Highly sophisticated hydroponic growing systems (Wan et al., 1994; Wheeler et al., 1990) might be technologically challenging for growers and conventional sub-irrigated pot techniques (Gosiewski and Skapski, 1984; Kratky, 1996) require too much growing medium to

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economically produce potatoes. Potatoes were successfully planted on a 2.5 cm deep layer of excelsior supported on wire netting above a nutrient solution tank and covered with 10 cm of excelsior, wheat straw and sawdust (Gericke, 1946).

The purpose of this study was to develop improved cultural information for growing potatoes by a passive sub-irrigation method in a plastic-covered rainshelter. Efforts were made to find an inexpensive growing medium, to minimize the quantity of required growing medium and to investigate the effects of seed tuber size and potato cultivars on this growing system.

MATERIALS AND METHODS

Experiments on container type, growing media, cultivars, seed tuber number and size were conducted in a polyethylene-covered rainshelter over a 5 year period at the Mealani Experiment Station (850 m elevation) in an attempt to develop a feasible growing system for high value potatoes in Hawaii. Nutrient solution (1.5 mS) depths of 2.5 to 5 cm were maintained in growing tanks (3.7 m long x 0.6 m wide) by gravity flow to float valves. Nutrient solution consisted of the following elemental ratios – 1950-N:792-P:3154-K:1900-Ca:640-Mg:20-B:5-Cu:40-Fe:20-Mn:1-Mo:5-Zn. There were at least 3 replications of each treatment and the experiments were arranged as randomized complete blocks.

Two or six ‘Catalina’ seed tubers (4, 20 and 52 g [$\pm 15\%$]) were planted in bottom-perforated 18.9-liter polyethylene bags (0.6 x 0.3 m spacing) supported by the tank floor. Bags were partially filled with 5.6 liters of a peat-perlite growing medium and filled with ‘hillings’ of dry grass as the season progressed. In another experiment, 2 seed tubers (40-60 g) per 18.9 liter bag of ‘All Blue’, ‘Catalina’, ‘Huckleberry’ and ‘Yukon Gold’ potatoes were grown similarly.

Two ‘Catalina’ potato tubers were planted in 11.4 and 18.9-liter bottom-perforated polyethylene bags supported by the tank floor and 3 tubers were planted in nursery trays (17x17x5 cm) elevated 5 cm above the tank floor such that there was an average tank spacing of 30 x 30 cm per plant. The bags and trays contained 2 liters of growing medium per potato seed tuber and these containers were subsequently ‘hilled’ 3 times with dry grass. In another experiment with a similar plant spacing, ‘All Blue’, ‘Catalina’, ‘Huckleberry’ and ‘Yukon Gold’ potatoes rested on 5-cm-high nursery trays without growing medium and where potato seed tubers in one treatment were wrapped in newspaper and other treatments included previously-described 18.9-liter bags and 10-cm slit-sided pots filled with peat-perlite growing medium and suspended by a 2.5 cm-thick expanded polystyrene top-cover for the tank. All 4 treatments were subsequently hilled with dry grass.

Bottom-perforated 8-liter pots containing upside-down 3-liter pots were filled with 5 liters of peat-perlite, silty clay loam soil or decayed wood chips and these pots rested on the tank floor. A 30 x 30 cm plant spacing was achieved by planting 1 ‘All Blue’ or ‘Yukon Gold’ seed tuber (40-60g) per pot.

RESULTS AND DISCUSSION

When 18.9-liter bags were planted with 4, 20 and 52 g ($\pm 15\%$) seed tubers, the total yields of salable potatoes were 5.20, 6.48 and 7.54 kg/m² of tank area, respectively (Fig. 1). Yields of small (8 g) and medium (47 g) potatoes were similar from all 3 seed sizes, but the yields of large (114 g) and X-large (270 g) were significantly higher from the 52 g seed tubers than from the 4 g seed tubers. Shoots from large tuber pieces developed more rapidly and produced plants with higher dry mass and leaf area than those from small tuber pieces (Cushman and Tibbitts, 1996). An ideal seed size range is between 43 and 71 grams (Bohl et al., 1995; Johnson, 1997).

Planting 2 or 6 seed tubers per bag did not result in a significant yield difference (6.74 and 6.16 kg/m², respectively.) This is not surprising, because there was no salable yield advantage to planting potatoes at a density of 13.9 tubers/m² as compared to 7.4 tubers/m² (Love and Thompson-Johns, 1999). Water consumption for this experiment was 52.8 ml/g of salable potatoes.

Two seed tubers (40-60g) of blue, white, red and gold colored potatoes were planted per 18.9-liter sub-irrigated bag. Total salable yields of 'Catalina' (white) and 'Yukon Gold' were statistically similar to 'All Blue', but greater than 'Huckleberry' [red] (Fig. 2). 'Yukon Gold' had the highest proportion of X-large potatoes (ave.- 324 g). Water consumption for this experiment was 54.1 ml/g of salable potatoes.

Total salable yields of potatoes growing in nursery trays (17x17x5 cm) elevated 5 cm above the tank floor and 11.4 and 18.9-liter bags bottom-perforated polyethylene bags supported by the tank floor were 5.4, 4.6 and 5.1 kg/m² (based upon tank area), respectively (Fig. 3). Yields from the nursery trays were significantly higher at $p=0.07$, but not at $p=0.05$ than the from 11.4-liter bags, although neither treatment was significantly different than the 18.9-liter treatment. Water consumption for this experiment was 45.0 ml/g of salable potatoes.

Despite a great savings of growing medium by hilling with dry grass, these treatments required 2 liters of commercial peat-perlite growing medium per plant or about 21.5 liters per m² of tank. Growing medium cost of US\$3.23/m² of tank was clearly too expensive to produce about 5 kg of salable potatoes and it was necessary to investigate other growing methods to reduce medium costs.

Growing in 10 cm pots filled with a peat-perlite medium resulted in a 70 per cent savings of growing medium without significantly reducing yields as compared to 18.9-liter bags (Table 1), but the growing medium cost remained above US\$1/ m² of tank and the small pots were somewhat restrictive to tuber development. Growing medium was completely eliminated by wrapping the seed tubers in newspaper which was hilled with dry grass. Mean yields from 3 potato cultivars growing by this method were statistically similar to the 18.9-liter bag treatment. However, yields from 'Yukon Gold' were more than double those from 'Catalina', thus indicating some cultivar preferences. The newspaper wrapping method required some skill and was time consuming such that it is not practical for commercial purposes. Poor results were obtained by placing seed tubers on 5-cm-high nursery trays without initial growing medium and hilling with dry grass. However, it is a common agricultural practice to place seed tubers on soil and cover with a layer of straw (Polomski et

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al., 2004), thus giving hope that a similar practice, properly executed, would be feasible in sub-irrigated tank culture.

Another approach to lowering the cost of growing medium is to use inexpensive materials. Three growing media (silty clay loam soil, semi-decayed wood chips and peat-perlite) were compared by placing 5 liters of growing medium in 8-liter, bottom-perforated pots with empty, upside-down 3 liter pots to save substrate. Yields from the inexpensive wood chip treatment compared favorably with the peat-perlite medium, but the soil treatment clearly yielded less (Figs. 4 and 5). Use of inexpensive growing media such as pine bark (Jones, 1997) and wood fiber (Bohne, 2004) have been successful in container culture.

CONCLUSIONS

Potatoes grew successfully when 2 seed tubers (52 g) were placed in 18.9-liter plastic bags containing 2 liters of peat-perlite growing medium per plant and the bags were filled with hillings of dry grass. The population density was 10.8 tubers/m² of tank. The bags were sub-irrigated in tanks containing 2.5 to 5 cm of nutrient solution (1.5 mS). Water consumption ranged from 45.0 to 54.1 ml/g of salable potatoes in 3 experiments. Attempts to reduce the amount of growing medium by growing in 10 cm pots and wrapping seed tubers in newspaper resulted in comparable yields as from the 18.9-liter bags, but the small pots were somewhat restrictive to tuber development and the newspaper wrapping process required some skill and was time consuming. Potatoes growing in an inexpensive decayed wood chip growing medium produced yields similar to those in a peat-perlite growing medium. Future experiments on using less growing medium, identifying inexpensive growing media and cultivar selection are recommended.

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Table.

Table 1. The influence of 4 sub-irrigated growing methods on the total salable yields of 3 potato cultivars. (Jan. 5- Apr. 12, 2004)

| Treatment | 'All Blue' | 'Catalina' | 'Yukon Gold' | Mean |
|-------------------|---------------------------|------------|--------------|--------|
| | Salable kg/m ² | | | |
| 18.9-liter bag | 5.06 bc ^z | 6.25 bc | 6.87 bc | 6.06 B |
| 10-cm pot | 5.27 bc | 5.10 bc | 6.58 bc | 5.65 B |
| Wrap in newspaper | 5.28 bc | 3.48 ab | 7.19 c | 5.32 B |
| No medium | 0.74 a | 1.03 a | 1.29 a | 1.02 A |
| Mean | 4.09 Y | 3.97 Y | 5.48 Z | |

^zMeans separation at 5% level (DMRT); capital letters between mean values, small letters between treatment values.

Figures

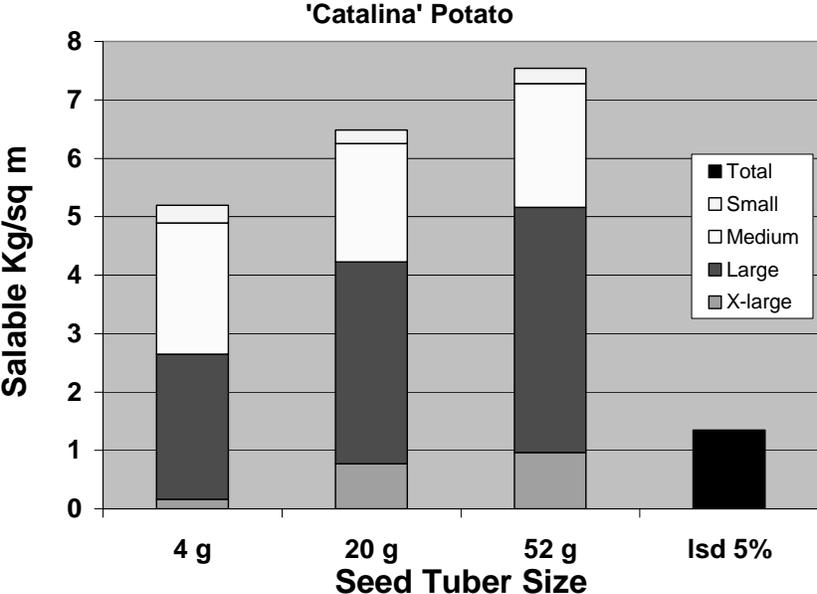


Fig 1. Salable yields of small (8 g), medium (47 g), large (114 g) and X-large (270 g) potatoes from sub-irrigated 18.9-liter bags planted with 4, 20 and 52 g ($\pm 15\%$) seed tubers.

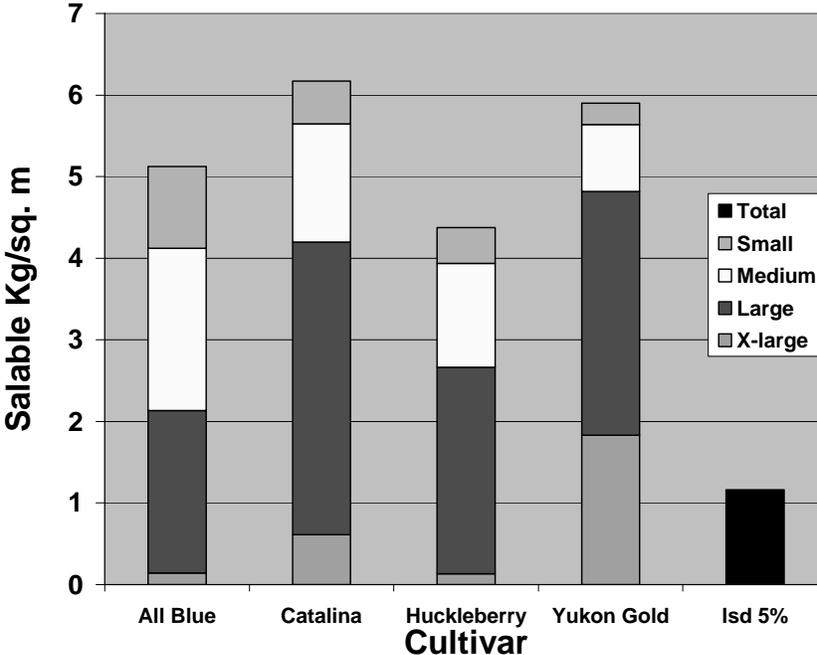


Fig 2. Salable yields of small (36 g), medium (79 g), large (156 g) and X-large (324 g) potatoes from sub-irrigated 18.9-liter bags planted with 4 cultivars. (Apr. 17 - Aug. 1, 2003).

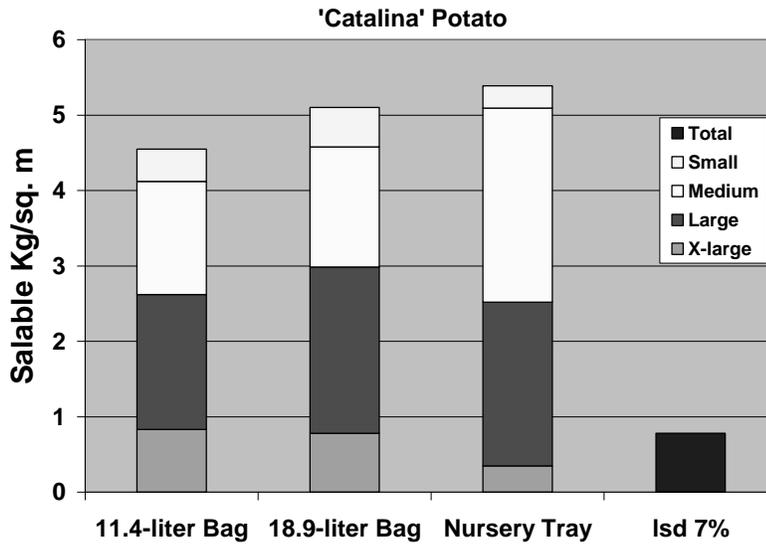


Fig 3. Salable yields of small, medium, large and X-large 'All Blue' potatoes growing in nursery trays (17x17x5 cm) elevated 5 cm above the tank floor and 11.4 and 18.9-liter bags bottom-perforated polyethylene bags supported by the tank. (Feb. 26 - June 7, 2002)

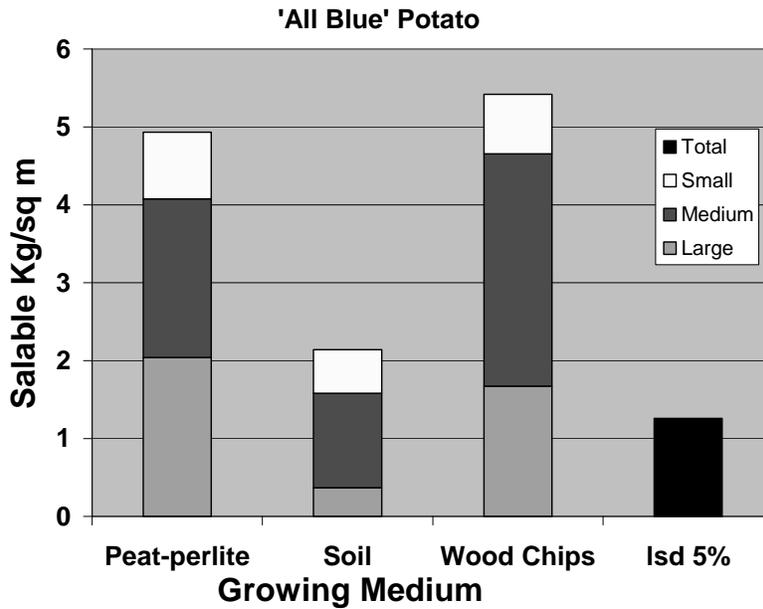


Fig 4. Yields of small (30 g), medium (79 g) and large (178 g) 'All Blue' potatoes growing in sub-irrigated, bottom-perforated 8-liter pots containing upside-down 3-liter pots which were filled with 5 liters of peat-perlite, silty clay loam soil or decayed wood chips. (May 10 – Sept. 2, 2005).

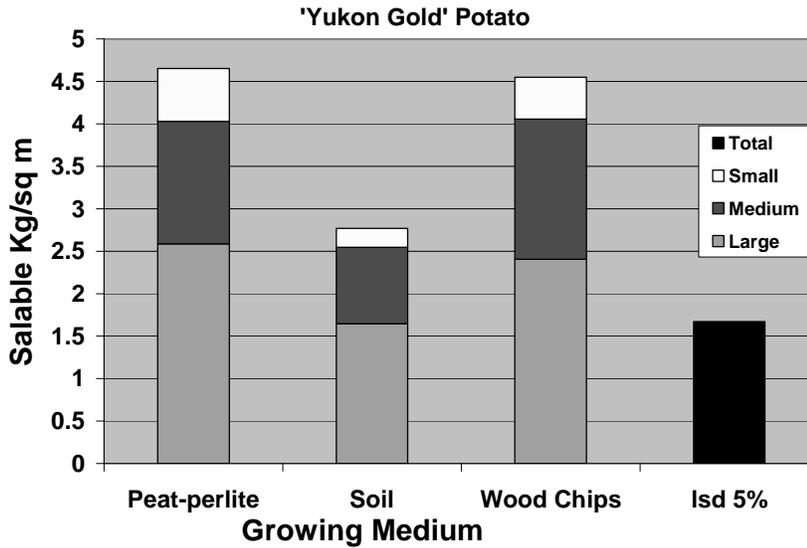


Fig. 5. Yields of small (36 g), medium (87 g) and large (192 g) 'Yukon Gold' potatoes growing in sub-irrigated, bottom-perforated 8-liter pots containing upside-down 3-liter pots which were filled with 5 liters of peat-perlite, silty clay loam soil or decayed wood chips. (May 10 – Sept. 2, 2005).